

Knot: an Interface for the Study of Social Networks in the Humanities

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ABSTRACT

This paper describes the design of Knot, a digital tool for exploring historical social networks, developed within a multidisciplinary research context involving designers, humanities scholars and computer scientists. The goal of the tool is to provide scholars and researchers with an environment for exploring multi-dimensional and heterogeneous data, allowing them to discover and create explicit and implicit relationships between people, places and events. What distinguishes our approach to traditional network exploration and analysis is an emphasis on the construction of the network graph through the visual interface, rather than on its static observation. Knot aims to explore new opportunities for interface design and information visualization within the definition of novel research practices in the humanities, bringing together scholars, HCI, design, and computer science communities.

Author Keywords

User Interface design; network visualizations; digital humanities; social networks; information visualization.

ACM Classification Keywords

H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces.

General Terms

Design.

INTRODUCTION

For the last few years, computers and the Internet have been changing the way research has been conceived, conducted, and communicated, transforming scholarly publication and

collaboration, and supporting the creation, the storage, the analysis, and the dissemination of data and information. While many areas of study within the natural, medical, and social sciences have a long and established tradition with these technologies, most of the humanities disciplines have found it difficult or inappropriate to integrate computational tools that are based mostly on quantitative approaches, into their research methods. In the last twenty years, however, new research areas and activities have emerged from the intersection between humanities and computing. Today, what is known as “digital humanities”, represents a heterogeneous set of studies and practices that aims at understanding the implications and the opportunities that digital technologies can provide as media, tools, or objects of study in the humanities [1, 2]. These new relationships between the digital and the humanities are rapidly demanding new modes of observation, exploration, and interpretation. Information visualizations and interfaces appear as essential tools to explore and make sense out of big and heterogeneous amounts of data [3]. But, in a context where most of the methods and the technologies are still adopted from other disciplines, the biggest challenge seems to be imagining new genuine research tools capable of embedding and valorizing humanistic inquiry [4]. However, despite the increasing attention that interfaces and visualizations are receiving among scholars and researchers, HCI and design communities show little interest or involvement in the discussion. As Burdick points out: “[...] within the digital humanities, most scholars continue to design their own projects or use research assistants or IT staff to do so. But the most troubling development is that these same scholars validate their approach by theorizing visual communication modes such as visual layout, the image, interaction, and multimedia with scant reference to the existing discourse within film, design, or the arts” [5].

The work presented here aims at making a step in the direction of deepening the relationships between designers, humanities scholars, and computer scientists in the definition of new research tools based on digital environments and data. In particular, a collaborative effort has been made in the design of a visualization tool for studying social networks from a humanities perspective.

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While the use of network visualizations is already well accepted in many disciplines and research contexts, when it comes to the humanities, visual tools capable of fully supporting the interpretative work of scholars with relational data are still missing. This paper collects and discusses the whole process that has led to the definition and the development of a first prototypal version of the tool, namely Knot, starting from the theoretical and the methodological assumptions behind the use of network visualizations in the humanities and ending up with the description of the final design. Further details about the approach and the principles that have guided the design are also provided.

BACKGROUND

Network graphs have a long tradition in Information Visualization. The graph model defined by nodes and links – relations between entities – represents a highly flexible layout that has found countless applications, especially in natural, social and computer sciences. Political, economical, social, semantic, biological, and chemical phenomena have been the object of network visualizations for years now [6, 7]. The common approach to network visualization is inspired by a desire of representing and analyzing the shape of the entire network graph to learn something about a particular dataset [8]. In particular, in the case of social studies and social network analysis, the user can make use of visualization of large social networks to identify cliques and see how they interact with the rest of the nodes or to perform network analysis, using quantitative methods for measuring social relationships (e.g. degree distribution, clustering, closeness, centrality, distance). From this perspective, a social environment can be expressed and represented in terms of relational patterns and regularities within the interacting units of the social space.

In the last years, several tools, such as Gephi [9] and Cytoscape [10], have been developed to perform network analysis and create complex network graph visualizations, focusing mostly on high quality layout algorithms, data filtering, clustering and statistics. These tools embed a visualization and exploration process characterized by the “overview first, zoom and filter, details on demand” browsing model typical of information visualization disciplines [11]. In such an approach, the “overview” provides a general context for understanding the dataset, the “zoom and filter” involves a reduction of the complexity of the data representation by removing extraneous information from the view and allowing for further data organization, and “details on demand” provide additional information on a point-by-point basis [12]. Despite the fact that no scientific evidence supporting this approach has ever been presented, it has been adopted by a great number of researchers and implemented in the graphical user interfaces of notable software, becoming a valuable source of inspiration for the design of exploratory data analysis methods [12]. This approach has become very popular, but

the observation of global patterns is not always relevant. In fact there is also a very large class of users who frequently deal with large network data but are not interested in global patterns in this data. Instead they are interested in how particular points in the dataset relate to the rest of the data.

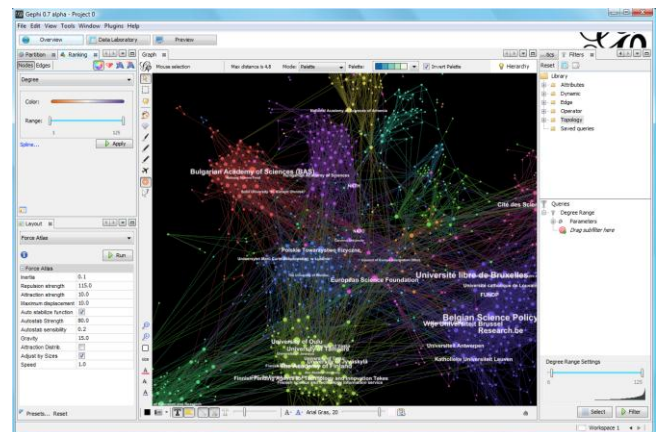


Figure 1. The interface of Gephi, one of the most popular network visualization tools [9].

Network Visualizations in the Humanities

When it comes to the humanities, network graphs have a much more recent history. Mostly coming from literary studies and text analysis (see Figure 2), graphs have been used to show and explore relationships between literary entities, such as texts, words, topics, genres or authors [13, 14]. In these fields, the network graph is a powerful conceptual and cognitive tool trying to exploit the heuristic potential of network visualizations. The concepts and methods of social network analysis have been adopted in historical research too, not only as a mere metaphor, —as has been the case in prosopographical studies— but also in practice. [15]. In the last few years many projects and initiatives have emerged with the goal of creating new ways to studying the vast digitized historical resources available today and more often network analysis methods and theories have been applied to historical data in various fields, for example in the study of correspondences, social movements, kinship and economic history [16, 17].

Within these contexts, the network graph model is used to explore bibliographical information and interconnected relationships between nodes (e.g. authors’ influences, friends and collaborators). In this sense the visualization, more than a mode of presentation, becomes, first of all, a method for exploring a particular dataset created from the digitization of historical sources.

However, the approaches and tools used in these research activities come mostly from other disciplines where network analysis, and in particular social network analysis, is an established practice. As mentioned above, these kinds of tools are mostly focused on the visualization of huge quantities of entities and relationships and in revealing the

structural properties of a network through quantitative analyses.

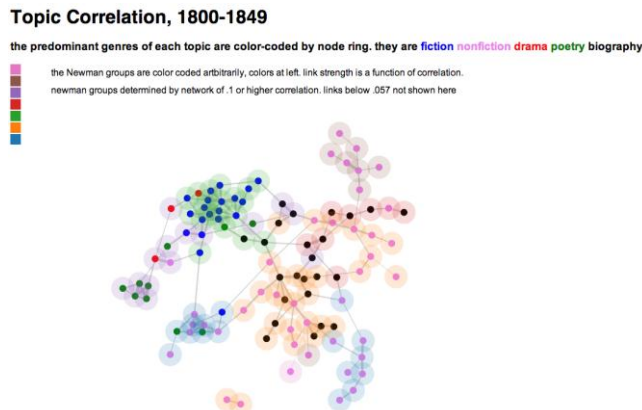


Figure 2. An interactive force-directed graph used for visualizing topic modeling in literary genres [14].

The digital humanities can no longer afford to take their tools and methods from disciplines whose fundamental epistemological assumptions are at odds with humanistic methods [4, 18]. Methodology appropriation is dangerous and “even when the people designing a methodology for some specific purpose get it right – and they rarely do – there is often a score of theoretical and philosophical caveats that get lost when the methodology gets translated” [19]. Stemming from these considerations and the current lack of digital tools designed specifically for the exploration of humanities and historical networks, we have elaborated and proposed here a new approach to the design of a visual interface that privileges the exploration and the construction of the network, instead of its static contemplation.

OUR APPROACH

A multidisciplinary collaboration

The need and the opportunity to focus on the design of a visual tool for the exploration of social networks stems from a collaboration between humanities scholars, communication designers and computer scientists that emerged within the context of the Mapping the Republic of Letters initiative (MRofL) [20]. MRofL is a digital humanities project based at Stanford University exploring intellectual exchange in the early modern period through the analysis of correspondence, travel and intellectual network data. Bringing together an international network of scholars, researchers, graduate students, collaborators, and partners through several research and learning initiatives, the project is a collection of case studies in history and literary studies that makes use of information visualization to examine the scope and the dimension of heterogeneous datasets. In the last four years, the MRofL research group has engaged with several research labs and organizations from the design and computer science communities, in order to better understand roles, opportunities and synergies

between these fields, in the development of digital humanities tools.

After several projects and prototypes realized together with the DensityDesign Lab at the Politecnico di Milano [21] and focused on the visualization of the correspondence network of some key historical figures of the project, the group has moved towards a deeper focus on the exploration of multidimensional connections between individuals deriving from the different case studies. As a result of this shift, the design of digital tools for the exploration and the study of networks in the humanities has become the next main effort of the group.

The “Early Modern Time and Networks” workshop

The first step, in order to better understand the opportunities and the limits related to the use of social network visualizations in the context of the MRofL project, has been the organization of a two-week workshop at Stanford University’s Center for Spatial and Textual Analysis (CESTA) [22]. The workshop, conceived as “a humanities + design collaboration to create tools for humanities research defined by humanities research questions and involving humanities scholars in the design and development process” [23], had several purposes:

- Testing and reviewing existing network visualization tools, using different case studies from humanities scholars and students.
- Discussing and defining needs and requirements for the design of a network visualization tool for the MRofL project.
- Bringing together designers, scholars, graduate students and developers in a discussion about the design and the use of digital humanities visualization tools.

The initiative involved scholars, researchers and graduate students from Stanford University and McGill University, designers and researchers from the DensityDesign Lab, and a team of developers from the Gephi Consortium, committed to the design of interactive network exploration platforms. Several case studies from the MRofL initiative have been used during the workshop. Each case study provided a context, a scenario and a dataset to work with. The case studies were made up of correspondence and travel data from the Enlightenment period focusing on individuals, intellectual communities, and/or geographical areas. For each case study, one or more graduate students were involved. The workshop format was chosen to provide a shared and informal environment to facilitate the discussions and the interactions between the scholars, the designers, and the developers. As a way to further enhance the communication between the participants, a live blog was used to collect and share experiences and comments about the ongoing activities, for the duration of the workshop. The main focus of the workshop was to engage with the relational dimensions of the data. By ‘relation’ we do not only mean the more explicit link that

correspondences represent, by connecting two or more people. In fact, the kind of multidimensional data involved in the MRofL project, present many different ways (dimensions) from which to look at them: letters, places, people, institutions and events can be seen as nodes or links of an intertwined network that can be defined and explored using ad-hoc defined criteria. This possibility to decide the criteria on which building and looking at the network, has encouraged the investigation of possible ways to model and visualize such relations.

Test and review of existing tools

A great part of the workshop was dedicated to observing the way scholars and students relate to the idea of network and how they approach existing tools for the visualization and the exploration of knowledge networks. By using the initial dataset related to each case study, the scholars and the students were encouraged to engage with several tools to model and visualize the data. More than specific and predetermined research questions, each case study brought in some very open questions, often driven by curiosity or by a more generic desire to explore the underlying data. Some interesting behaviors and outcomes emerged at the level of single case studies and in a more generic approach with the tools and the processes of investigation by the students. The observation of the scholars and the students working with the tools to manipulate and visualize the data (i.e. OpenRefine [24] and Gephi [9]) has been particularly helpful to understand their way of dealing with this loose and abstract idea of 'relations' in the data, their confidence and appreciation of network graphs, as well as some more generic features and limitations of the tools.

A first consideration comes directly from the use of the visualization tools, concerning the high flexibility and effectiveness that this kind of tool presents in conveying a synthetic view of (relational) data. In fact, while many of the students have never used a tool to visualize network data, most of them have immediately understood how to produce and read graphs about social connections in their data. For the first time, the students have had an overview of the intricate network of relationships in their case study, in a single snapshot. In this sense, network graphs have proved to be particularly helpful to highlight some emerging patterns and trends. Some main features of the network can be indeed easily depicted, especially the ones related to its connections (e.g. the number of letters exchanged between the individuals), distributions (e.g. which individuals have central or bridging roles) or segmentations (e.g. the emergence of groups or clusters).

However, together with these enthusiastic reactions, some limitations of the tools emerged as well. Regarding the network graph tools, the main concerns involve the low level of interaction they provide with the data and the visualizations. In order to produce a graph, these tools require identifying all the nodes and the links a priori: each node can have some metadata, to be filtered on, and so have

links. Data with this information are loaded into the tool that performs the visual representation, according to some parameters chosen by the user, such as metadata encoding, by using standard graphical variables (e.g. color, size, opacity). While this represents surely an effective and easy way to create a network graph, it is based on an idea of network coming especially from biological sciences [10], where the primary goal is to navigate huge numbers of entities and connections and, especially, to perform network analysis (e.g. degree distribution, clustering, closeness, centrality, distance). While these methods can be surely applied on humanities networks too, they look more like a starting point for an overview of the network, rather than a way to define and iteratively navigate the relationships.

Network visualization tools, such as Gephi or Cytoscape, tend to consider the information coming from the network as the only source available on the observed phenomenon. On the contrary, each of the scholars and the students of the workshop had a deep knowledge about every single node of the network (e.g. a person, a place or an event) beside the information contained in the network itself. Together with looking at the whole picture, they often need a way to integrate the network with information they possess and that could not be easily formalized into metadata. Moreover, by looking at the graph, the students expressed the desire to act on the visual disposition and the composition of the elements, by re-orienting, grouping, moving, deleting, and adding nodes and links.

Discussions

In order to gather and further elaborate on what we learned from the first observational phase of the workshop, a series of informal discussions was organized. Each participant was encouraged to express and articulate his or her experience with the use of the visualization tools as well as other ways they might prefer to engage with the relational dimensions of the data. The discussions had several purposes: on the one hand, a systematic collection of the critical elements that emerged during the tests and, on the other hand, the definition of some first requirements and guidelines for the development of some basic prototypes.

Prototypes and iterations

The last part of the workshop was dedicated to the development of some basic tests and prototypes. Encouraged by the possibility of producing interactive visualizations in a short time, especially thanks to the Web technologies and the strong iterations between the designers and the developers, we conceived of this as a fast and lightweight way to experiment with the data and the users. In this way, based on previous experiences with the existing tools, several aspects related to the visual and the interactive dimensions of the tools were briefly explored and discussed. Building and testing the prototypes in the context of the interdisciplinary group, increased general awareness of the implications of the technologies involved

in developing these kinds of tools, both in terms of opportunities and limitations. Moreover, this shared effort provided those involved with a common language, thereby reducing the knowledge gap between designers, computer scientists, and humanities scholars.

DESIGN PRINCIPLES

As a result of the workshop and the first experiences with the prototypes, several principles have been identified as guidelines for the design of a graphing tool for the exploration of historical social networks.

The interface as an environment for interpretative activities

While visualization is often conceived as the last step in the exploration of the data, our idea is, instead, to put it in the middle of a broad process of understanding and exploration [25]. In this way, the whole tool (not just the visualization itself) has to be considered as an environment for engaging with the data in interpretative and generative activities. It has to combine different views on the data: moving from the micro to macro scale, providing the big picture as well as specific details.

Allowing the construction of the network

As we have seen, one of the main limitations of the existing network visualization tools is their inability to deal with a more flexible and iterative definition of the network. As the experience of the workshop has shown us, this does not fit well with the kind of exploration the scholars want to achieve. Stemming from these considerations, with this principle we move away from the idea of the visualization tool as a ‘graph renderer’, where the visualization follows a close and *a priori* definition of the data to be represented. Instead, the idea here is to look at the visualization space as a ‘canvas’, where the domain expert can define her own definition of the network, by adding and removing nodes and links from heterogeneous sources, by formulating and validating hypotheses, taking a more heuristic approach with the tool. In this sense, this principle also addresses the long-standing question within the design of interfaces for the humanities, as posed by John Unsworth: “can we structure an interface that is sufficiently generalized that it can accommodate interest in many different kinds of features, without knowing in advance what they will be? How can we make visualizations function as interfaces, in an iterative process that allows the user to explore and tinker?” [26].

Exploiting the multidimensional nature of the data

While the network visualization, as we have seen during the workshop, is a very effective way to obtain a big picture of relationships in the data, it is also true that a reference to the context in which the network lies is often necessary for domain experts. In particular, the spatial and temporal dimensions were revealed as critical to a better understanding of the elements and the relations within the

network, to place them within the context of the cultural and historical phenomena surrounding them. Moreover, the different attributes of nodes and links should be exploited for the creation of those implicit networks coming from loose affiliations and heterogeneous categorizations, including those defined by the scholars, through interaction with the visualization.

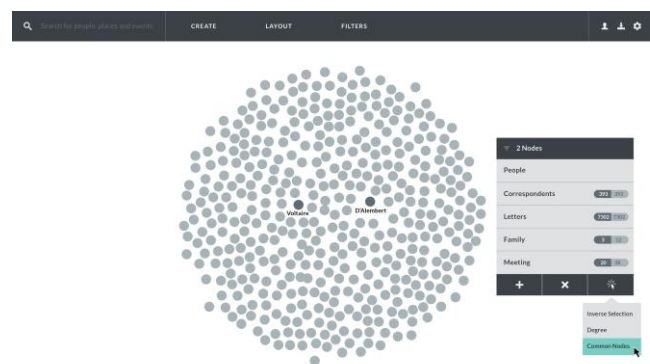


Figure 3. Knot's interface. The nodes are visualized in the main canvas and the user can select them singularly or through multiple selections with the mouse or a set of feature present in the right panel.

Understanding and revealing data sources

Understanding the origin behind each single piece of information used in the tool is crucial for humanities scholars. More than in other fields, the question about “what data are” and “where they come from” is, at the same time, particularly difficult to answer and highly relevant in the humanities. As Borgman points out, “the humanities and arts are the least likely of the disciplines to generate their own data in the forms of observations, models, or experiments” and “any record of human experience can be a data source to a humanities scholar” [27]. Starting from these considerations and the nature of the historical data of the MRofL project, particular attention has to be paid to ensure the maximum transparency on exposing the sources of the data as well as all the processes it has been passed through. At any time the user of the tool should be able to understand which information the visualizations are referring to and what else is available about it. Moreover, in order to allow the user to export the results of his investigations outside of the visualization tool, the possibility to export images (raster or vector) has to be provided, as well as the ability to export the data and the source references.

Data manipulation and enrichment

The data coming from MRofL, as from many other humanities projects, present a high level of uncertainty and incompleteness for a number of reasons, such as the nature of the data itself (e.g. letters from the XVII century), the process of acquisition and digitization (e.g. letters are handwritten making it difficult, if not impossible, to

recognize and process the content) and the heterogeneity of different sources (e.g. each data collection provides different content and metadata). These aspects, together with the need of including levels of interpretation and annotation within the data, have led to the idea of providing the manipulation, the enhancement and the creation of data directly through the interface. In fact, the workshop has shown us the tendency scholars have to group the nodes on the basis of their own personal interpretation, and thus, the need of adding new metadata (e.g. new categories) to the data. More specifically, this idea has led to the definition of two macro behaviors to be included in the tool: the first one is the use of the network visualization for the creation of new metadata, while the second one is the definition of node clusters to observe the relationships existing between them.

KNOT

Knot, as we named the tool, aims at supporting humanities scholars in their research, not only by retrieving information from the MRofL archive, but by shaping the research process in an alternative way through the use of a rich visual interface. Starting from the design principles we have defined before, the observations made during the workshop and after some first preliminary prototypes, we decided to design a web-based application to display and interact with the MRofL data using network graphs and other visualizations. In this chapter we will provide an overview of the final design and the features included in the tool.

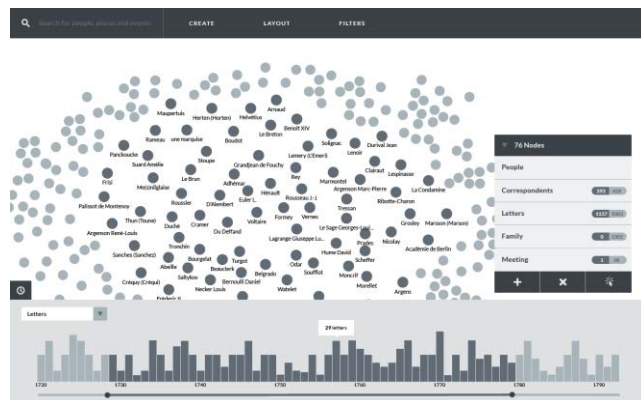


Figure 4. The interactive timeline to explore and filter temporal data.

The main canvas

The central part of the interface is dedicated to the “canvas” where the user can operate a series of interaction on the graph, such as adding, removing and moving nodes and links. By default, the nodes will be represented as grey dots

disposed in a random layout and without edges, in a way the user is not influenced by some spatialisation algorithm and graphical variables predefined by the designer of the tool. Aware of the fact that scholars are not completely satisfied by a global approach to the visualization of networks proposed by existing tools, we decided to adopt a local approach where users can decide where to start their exploration.

Searching and adding nodes

The search box in the upper left corner gives the possibility to search the archive for a particular person or a group of people that share some attributes (e.g. born in the same country) and to add them into the canvas. An autocomplete feature helps the user during the search query, suggesting the available data that match the request and giving some basic biographical information (birth and death date), in order to disambiguate homonyms.

Selecting nodes and expanding relationships

The user can select the nodes singularly or through multiple selection features. A panel on the right shows the main information for the selected nodes and allows the user to add explicit relationships of the nodes or removing them from the canvas. Moreover, the user can select other nodes through a set of features (i.e. inverse selection, selecting a certain degree, selecting common nodes between two or more nodes). In this way Knot allows the user to decide which nodes to add to the canvas and create the visualization in an iterative process.

Creating new nodes and relationships

By selecting “Create” on the top menu, the user can add new nodes and new relationships between individual nodes, to enrich the data or to experiment with some hypotheses. Once the scholar have selected this option, a pop up appears, allowing the record of some basic information about the new node or the new relationship that can later be added to MRofL archive and thus used by other researchers.

Layout

By selecting the “Layout” option from the top menu, the scholar can modify the visualization of the network graph by choosing the spatialisation layout, the edges to be visualized and which attribute using for sizing the nodes. In addition to the initial “random layout”, the user can decide to apply one of the following layouts:

- *Force directed layout*: it is an algorithm for drawing graphs in an aesthetically pleasing way. The purpose is to position the nodes of a graph in the space so that all the edges are of more or less equal length and there are as

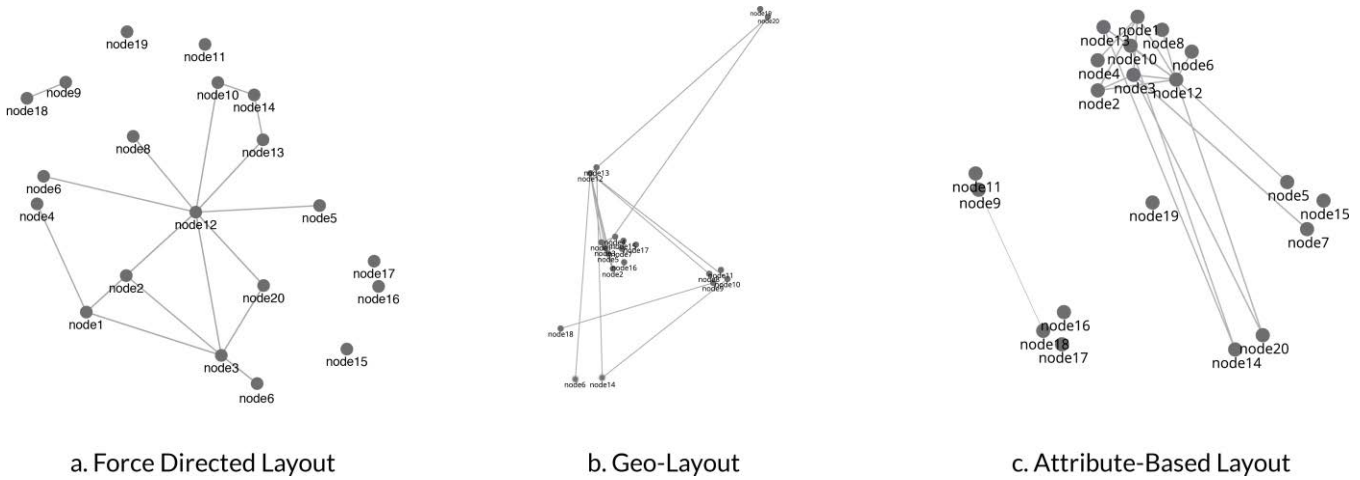


Figure 5. The spatial layouts available for the network graph.

few crossing edges as possible, by assigning forces among the set of edges and the set of nodes, based on their relative positions, and then using these forces either to simulate the motion of the edges and nodes or to minimize their energy (see Figure 5a).

- *Geographical layout*: this layout places the nodes according to a geographical attribute decided by the user (e.g. place of birth). The result is a georeferenced visualization that allows the user to discover the geographical dimension of the nodes in the canvas (see Figure 5b).
- *Attribute-based layout*: this layout groups the nodes by clusters according to a node attribute selected by the user (e.g. occupation). The result is a visualization where nodes with the same attribute value are placed next to each other. If a node has more than one value for the selected attribute (e.g. a person who is both a philosopher and a mathematician) it will be placed halfway between the clusters of those values (see Figure 5c).

At any moment during the process of exploration, users can drag and place the nodes where they prefer, acting directly on the network graph. Likewise, through the “layout” panel, the scholar can decide to show or hide the edges representing the explicit relationship and to show or not their directionality and weight.

Filtering

Through the “Filter” panel, available in the top menu, the user is able to see all the attributes related to the nodes on the canvas (e.g. people’s expertise, places of death and birth or affiliation to a club or academy). The user can decide to filter the nodes according to one or more attributes or to simply explore the composition of the network. The filters present a faceted browsing system similar to the Elastic Lists proposed in [28]. An interactive timeline, at the

bottom of the interface, allows the user to look at the temporal distribution of a selected dimension (e.g. the number of letters sent and received by the nodes in the canvas). Moreover, the timeline works as a temporal filter for the canvas view.

Grouping

As we have seen, the possibility of creating new metadata has been one of the features desired by the scholars. In addition to the creation of nodes and relationships the user can also add new attributes to the nodes and visually group them according to the values. In order to do that, the user, after the selection of a node, can simply drag it over another one to form a new group (see Figure 6). The new attribute, created from this action, will be automatically added in the “Filters” panel, where the user can specify additional information about the new attributes and use the metadata in other sessions.

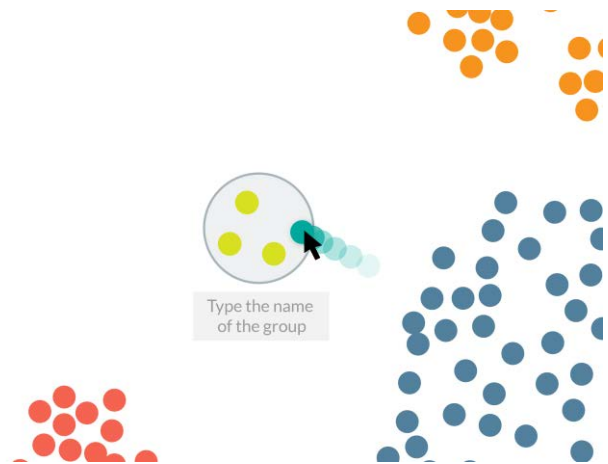


Figure 6. Grouping nodes by dragging them.

CONCLUSIONS AND FUTURE WORK

In this paper we have presented Knot, a collaborative effort between designers, humanities scholars, and computer scientists in the definition of visual tools for the exploration of historical social networks. Stemming from the need of supporting the interpretative work of scholars in dealing with relational data, the project has focused on the design of a digital environment to perform the exploration and the creation of explicit and implicit relationships between people, places and events coming from correspondence data. A review of available tools and approaches to the visualisation of networks has been initially provided, combining theoretical considerations with the insights obtained from the direct engagement with humanities scholars and students. As a result, some design principles have been defined and elaborated, providing a guideline for the actual development of the tool. Finally, the design of the prototype has been presented and discussed.

As a first prototype, Knot has thus far been used within the MRofL project by scholars and graduate students in History and Literature. As future work, we plan to proceed with a deeper evaluation of the prototype and the design principles embodied in it, especially in other research contexts and using different data sources. Moreover, we aim to further explore the collaboration between design, humanities and computer science in the definition of new digital methods and tools for historical and cultural research.

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